(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 178 589 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication: 06.02.2002 Bulletin 2002/06

(21) Application number: 00921086.5

(22) Date of filing: 27.04.2000

(51) Int Cl.7: H02K 41/03

(86) International application number: PCT/JP00/02808

(87) International publication number: WO 00/69051 (16.11.2000 Gazette 2000/46)

(84) Designated Contracting States: AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: 07.05.1999 JP 12708199
24.02.2000 JP 2000052265

(71) Applicant: Hitachi, Ltd.
Chiyoda-ku, Tokyo 101-8010 (JP)

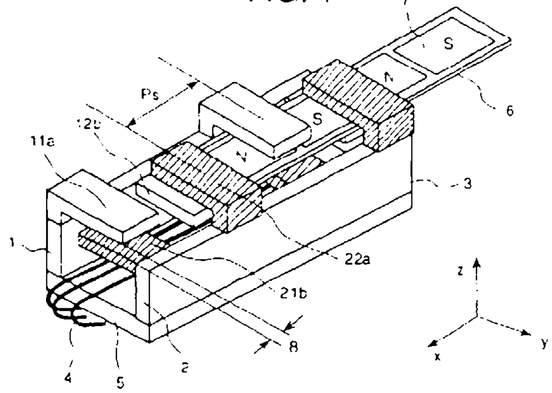
(72) Inventors:
- KIM, Houng Joong
Hitachi Res. Lab., Hitachi, Ltd.
Hitachi-shi Ibaraki 319-1292 (JP)
- KATAYAMA, Hiroshi
Automotive Prod. Hitachi, Ltd.
Hitachinaka-shi Ibaraki 312-0062 (JP)
- MAKI, Kohji Hitachi Res. Lab. of Hitachi, Ltd.
Hitachi-shi Ibaraki 319-1292 (JP)

(74) Representative: Strehl Schübel-Hopf & Partner
Maximilianstrasse 54
80538 München (DE)

(54) **LINEAR MOTOR AND PRODUCTION METHOD THEREFOR**

(57) Inorder to educe the magnetic flux leak through the gap between the magnetic pole teeth of the armature so as to reduce the magnetic attraction force generated between the armature and the needle, an armature unit, comprising an armature core 5 to be wound with an armature coil 4 and two magnetic poles 1 and 2, is constructed on the top of which there are provided magnetic pole teeth 11a, 12b, 21b, and 22a protruding toward the opposing magnetic pole, where the magnetic pole teeth of the magnetic pole 1 are arranged in two heights, upper and lower, so that the (2n-1)-th tooth (n=1, 2, 3, ...) protrudes as the upper one and the (2n)-th tooth (n=1, 2, 3, ...) protrudes as the lower one and the magnetic pole teeth of the opposing magnetic pole 2 are arranged in two heights, upper and lower, so that the (2n-1)-th tooth (n=1, 2, 3, ...) protrudes as the lower one and the (2n)-th tooth (n=1, 2, 3, ...) protrudes as the upper one, and the magnetic flux flows upward and downward alternately between the upper and lower magnetic pole teeth, wherein the needle 6 equipped with permanent magnets moves relatively in the gap 8 between the upper and lower magnetic pole surfaces of the armature unit.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[Field of the Invention]

[0001] The present invention relates to a linear motor and a manufacturing method thereof, particularly to a linear motor and a manufacturing method of a linear motor wherein there are provided an armature on which a coil is to be wound and magnetic poles with pairs of opposing magnetic pole teeth, upper and lower, which are arranged alternately.

[Prior Art]

[0002] It has been known conventionally that, if the magnetic field of a linear motor is generated by a permanent magnet, high thrust can be attained with a compact construction. Thus, various constructions have been thought out for a linear motor.

[0003] Japanese Application Patent Laid-Open Publication No. SHO 63-310361 discloses a linear pulse motor that can be manufactured at lower cost by means of simplified lead treatment. While details are described in the Publication, the brief construction of the linear motor is as follows and as shown in Fig. 12.

[0004] Inside a straight armature 3 having a U-shaped section, there are fixed in parallel two yokes also having a U-shaped section, and a coil 4 is wound longitudinally on the bottom of each yoke. Each yoke is equipped with two magnetic poles standing upright. A magnetic pole plate is fixed on the top of each magnetic pole, where magnetic pole teeth 20 at an equal interval protrude toward the other magnetic pole plate, thus alternating the magnetic pole teeth 20 and forming a crow pole type magnetic pole surface. A needle 6, which is so held as to be able to move along the longitudinal direction of the armature 3, is equipped with two sets of permanent magnets 7 in parallel with each other so as to face with the magnetic pole surface through air gap and the permanent magnets 7 are so magnetized that the polarity alternates at the same interval as the protruding teeth of the magnetic pole plate. With this construction, when two-phase sine wave current with 90-degree phase shift is supplied to the coil 4 wound on each yoke, the needle 6 moves on the armature 3 along the longitudinal direction because of the well-known linear motor mechanism.

[Problems to be Solved by the Invention]

[0005] According to a prior art, while a linear motor can be manufactured at lower cost by means of simplified construction and simplified lead treatment, it involves the following problems. That is, because the two magnetic poles and magnetic pole plates provided for the armature 3 are so constructed as explained above, the magnetic flux leak through the gaps between the alternating magnetic pole teeth 20 protruding from the top of the two magnetic poles is large as a whole. As a result, the thrust of the motor is lower as compared to the exciting current. In addition, since a magnetic attraction force acts between the armature 3 and the needle 6 in one way, a greater burden is put on the support mechanism of the needle 6 and consequently strain is caused in the construction, resulting in various troubles.

SUMMRY OF THE PRESENT INVENTION

[0006] An object of the present invention is to offer a linear motor and a manufacturing method thereof, wherein the flux leak through the gaps between the magnetic pole teeth of the magnetic pole plates is reduced so that the magnetic attraction force between the armature and the needle is minimized.

[Means for Solving the Problems]

[0007] In order to achieve the above object, there is provided a linear motor comprising an armature and a needle with magnetism, the armature being equipped at least with a magnetic pole of the first polarity having the first opposing section and another magnetic pole of the second polarity having the second opposing section, and the needle being placed between the first opposing section and also between the second opposing section.

[0008] There is also provided a manufacturing method of a linear motor comprising an armature and a needle having magnetic poles, wherein an armature core to be wound with a coil, magnetic poles on both sides and a magnetic pole unit integrated from upper magnetic pole teeth and opposed lower magnetic pole teeth are manufactured separately from laminated steel plate to form an armature unit and an armature equipped with a magnetic pole of the first polarity having the first opposing section and another magnetic pole of the second polarity having the second opposing section is constructed by assembling the separately manufactured armature unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic drawing of linear motor according to an embodiment of the present invention.
Fig. 2 is a sectional view of linear motor in Fig. 1.
Fig. 3 is a conceptual diagram of magnetic flux flow of linear motor in Fig. 1.
Fig. 4 is a linear motor comprising two armature units of the present invention in series.
Fig. 5 is a linear motor comprising two armature units of the present invention in parallel.
Fig. 6is a schematic drawing of series arrangement of armature units according to another embodiment of the present invention.

Fig. 7 is a schematic drawing of needle according to another embodiment of the present invention (first)

Fig. 8 is a schematic drawing of needle according to another embodiment of the present invention (second)

Fig. 9 is a schematic drawing of needle according to another embodiment of the present invention (third)

Fig. 10 is a sketch showing a manufacturing method of linear motor according to the present invention

Fig. 11 is a sketch showing another manufacturing method of linear motor according to the present invention

Fig. 12 is a schematic drawing of linear pulse motor according to a prior art

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[Description of the Preferred Embodiments]

[0010] The preferred embodiment of the present invention is explained hereunder, using the drawing figures.

[0011] Fig. 1 is a schematic drawing of a linear motor according to an embodiment of the present invention, and Fig. 2 shows its sectional view.

[0012] In Fig. 1, 1 is a magnetic pole, 11a is an upper magnetic pole tooth of the magnetic pole 1, 12b is a lower magnetic pole tooth of the magnetic pole 1, 2 is another magnetic pole, 21b is a lower magnetic pole tooth of the magnetic pole 2, 22a is an upper magnetic pole tooth of the magnetic pole 2, 3 is an armature, 4 is an armature coil, 5 is an armature core, 6 is a needle, 7 is a permanent magnet, 8 is a gap between the upper magnetic pole tooth 11a of the magnetic pole 1 and the lower magnetic pole tooth 21b of the magnetic pole 2 (or between the lower magnetic pole tooth 12b of the magnetic pole 1 and the upper magnetic pole tooth 22a of the magnetic pole 2), and Ps is a center-to-center pole pitch between two adjacent magnetic pole teeth on the same upper or lower side. The armature 3 is equipped with the magnetic poles 1 and 2 on both sides of the armature core 5 at the bottom, and the armature coil 4 is wound longitudinally on the armature core 5 which is a long and straight core having a U-shaped section. Thus, the armature 3 has two magnetic poles 1 and 2.

[0013] While the magnetic pole 1 is equipped on its top with an upper magnetic pole tooth 11a, a lower magnetic pole tooth 12b, an upper ..., protruding towards the magnetic pole 2, the magnetic pole 2 is equipped on its top with a lower magnetic pole tooth 21b, an upper magnetic pole tooth 22a, a lower ... protruding towards the magnetic pole 1. That is, the protruding magnetic pole teeth of the magnetic pole 1 are arranged in two heights, upper and lower, so that the (2n-1)-th tooth (n=1, 2, 3, ...) protrudes as an upper one and the (2n)-th tooth (n=1, 2, 3, ...) protrudes as a lower one. To the contrary to the magnetic pole 1, the magnetic pole teeth of the magnetic pole 2 are arrange also in two heights so that the (2n-1)-th tooth (n=1, 2, 3, ...) protrudes as a lower one and the (2n)-th tooth protrudes as an upper one. When the whole upper magnetic pole teeth of the magnetic pole 1 and magnetic pole 2 are defined as an upper magnetic pole surface and the whole lower magnetic pole teeth as a lower magnetic pole surface, this construction means to provide two magnetic pole surfaces, upper and lower, where the opposing magnetic pole teeth of the magnetic pole 1 and magnetic pole 2 are alternated.

[0014] Here, a pair of the first upper magnetic pole tooth 11a and lower magnetic pole tooth 12b is defined as the first opposing section and the second lower magnetic pole tooth 21b and upper magnetic pole tooth 22a as the second opposing section. Consequently, the armature is so constructed that the (2n-1)-th pair comes as the first opposing section and the (2n)-th pair comes as the second opposing section.

[0015] When a constant gap 8 is provided between the upper magnetic pole tooth and lower magnetic pole tooth of each opposing section and a needle having magnetism is put through the gap 8, there is provided a construction where the needle is held between the first opposing section and also between the second opposing section.

[0016] With the above construction, there is provided an armature unit where the magnetic flux flows upward and downward alternately between the upper and lower magnetic pole teeth in the gap between the upper and lower magnetic pole teeth of each opposing section of a linear motor according to the present embodiment and the needle moves relatively through the gap.

[0017] In Fig. 2, a support mechanism (on the armature side) 14 supports the relatively moving needle 6 onto the armature 3 side and a support mechanism (on the needle side) 15 supports the relatively moving needle 6 onto the needle 6 side. The needle 6 supported by the support mechanisms 14 and 15 moves relatively in the gap 8 as if running in a tunnel.

[0018] In a linear motor according to the present embodiment, there are provided two different magnetic pole teeth, upper and lower, of the armature 3 and the needle 6 moves relatively between the upper and lower magnetic pole teeth. Provided that the distances from the center of the needle 6 to the upper and lower magnetic pole teeth are equal, the attraction force acting between the needle 6 and the upper magnetic pole teeth is equal to but the direction is opposite to the attraction force acting between the needle 6 and the lower magnetic pole teeth. Thus, the attraction forces cancel each other to become zero as a whole. As a result, the attraction force between the needle 6 and the magnetic pole teeth of the armature 3 can be reduced and accordingly a burden on the support mechanisms 14 and 15 can be minimized.

[0019] Fig. 3 is a conceptual diagram showing the

magnetic flux flow of a linear motor according to the present embodiment. When the armature coil 4 is excited, and if the upper and lower magnetic pole teeth of the magnetic pole 1 are magnetized to N polarity, the upper and lower magnetic pole teeth of the magnetic pole 2 are magnetized to S polarity. When this happens, the magnetic flux flows from the upper magnetic pole tooth 11a of the magnetic pole 1 to the lower magnetic pole tooth 21b of the magnetic pole 2 and similarly from the lower magnetic pole tooth 12b of the magnetic pole 1 to the upper magnetic pole tooth 22a of the magnetic pole 2. As a result, the direction of the magnetic flux flow in the gap 8 between the upper and lower magnetic pole surfaces reverses at every magnetic pole pitch.

[0020] In a linear motor according to the present embodiment, because of the above, the magnetic flux flows from the upper magnetic pole teeth toward the lower magnetic pole teeth through the N pole and S pole of the permanent magnet of the needle 6 and also from the lower magnetic pole teeth toward the upper magnetic pole teeth through the S pole and N pole of the permanent magnet of the needle 6. As a result, the magnetic path of a magnetic circuit of effective fluxes becomes shorter, magnetic resistance becomes lower, effective magnetic flux increases, and magnetic flux leak decreases.

[0021] On the other hand, since a conventional crow pole type linear motor has only a single magnetic pole surface, the magnetic flux from the N pole teeth of the armature 3 flows across the S pole and N pole of the permanent magnet of the needle 6 and returns to the S pole teeth of the armature 3. Hence, the magnetic path of a magnetic circuit of effective fluxes becomes longer. As a result, in a conventional crow pole type, the magnetic resistance increases and the magnetic flux leak not flowing through the permanent magnet of the needle 6 but flowing directly from an N pole tooth to an adjacent S pole tooth of the armature 7 increases.

[0022] Next, a linear motor comprising multiple armature units in Fig. 1, arranged in series or in parallel, is explained hereunder. Fig. 4 shows a linear motor comprising two armature units in Fig. 1 arranged in series.

[0023] Generally, in Fig. 4, an armature unit A and an armature unit B are arranged in series so that the pitch between the magnetic pole tooth "a" of the armature unit A and the magnetic pole tooth "b" of the adjacent armature unit B is $(K P+P/M)$ {(K=0, 1, 2, ...), (M=2, 3, 4, ...)}. P represents the magnetic pole pitch (either the armature magnetic pole pitch Ps or needle magnetic pole pitch Pm is selected), and M represents the phase of the motor. Namely, K=3 and M=2 apply in Fig. 4.

[0024] In Fig. 4, the armature magnetic pole pitch Ps can be either equal to or different from the needle magnetic pole pitch Pm. Making the armature magnetic pole pitch Ps equal to the needle magnetic pole pitch Pm is effective for reducing the thrust pulsation acting between the permanent magnet 7 and the magnetic pole teeth. The needle 6 is equipped with multiple permanent magnets 7 so that the polarity is alternated between two adjacent magnetic poles and that the magnetism is directed toward Z in Fig. 2.

[0025] When the needle 6 is held in the gap 8 between the upper and lower magnetic pole surfaces of the armature unit A and armature unit B by the support mechanisms 14 and 15 as shown in Fig. 2 and the armature coil 4 of the armature unit A and that of the armature unit B are excited alternately, the magnetic flux flows in the gap 8 between the upper magnetic pole surface and the lower magnetic pole surface in an alternate direction at every magnetic pole pitch. Thus, a thrust is generated as a result of P/2 essential for a movement, and the needle 6 moves relatively.

[0026] As explained above, arranging two armature units in series constructs a linear motor where the needle 6 moves relatively through a gap between the upper magnetic pole surface and lower magnetic pole surface of the armature units A and B.

[0027] Although the above explanation covers an arrangement of two armature units in series as shown in Fig. 4, the same applies to an arrangement of multiple armature units in series.

[0028] Fig. 5 shows a linear motor comprising two armature units in Fig. 1 arranged in parallel. As shown in Fig. 5, the armature unit A and the armature unit B are arranged in parallel and completely alongside, each needle is equipped with multiple permanent magnets 7 so that the polarity is alternated between two adjacent magnetic poles, and the needle 6a and the needle 6b are combined into a piece. In doing this, the needle 6a is shifted from the needle 6b by a pitch of P/2. Relatively speaking, it is also permissible that the needle 6a and the needle 6b are integrated completely alongside but that the armature unit A is shifted from the armature unit B by a pitch of P/2.

[0029] In the parallel arrangement in Fig. 5, the armature magnetic pole pitch Ps can be either equal to or different from the needle magnetic pole pitch Pm as in the series arrangement in Fig. 4.

[0030] In a similar manner as in Fig. 4, when the needle 6a and needle 6b are held in the gap 8 between the upper and lower magnetic pole teeth of the armature unit A and armature unit B, respectively by the support mechanisms 14 and 15 as shown in Fig. 2 and the armature coil 4 of the armature unit A and that of the armature unit B are excited alternately, the magnetic flux flows in the gap 8 between the upper magnetic pole surface and the lower magnetic pole surface in an alternate direction at every magnetic pole pitch. Thus, a thrust is generated as a result of P/2 essential for a movement, and the needle 6 moves relatively.

[0031] As explained above, arranging two armature units in parallel and combining two needles into a piece constructs a linear motor where the needle 6a and needle 6b move relatively through a gap between the upper magnetic pole surface and lower magnetic pole surface of the armature units A and B, respectively.

[0032] Although the above explanation covers an arrangement of two armature units in parallel and combination of two needles into a piece as shown in Fig. 5, the same applies to an arrangement of multiple armature units in parallel and combination of multiple needles into a piece.

[0033] In an arrangement of multiple armature units in series or in parallel, if the armature units or needles are combined into a piece so that the pitch either between the magnetic pole teeth of two adjacent armature units or between the magnetic poles of two adjacent needles is (K.P+P/M) {(K=0, 1, 2, ...) (M=2, 3, 4, ...)} as explained above, each can move relatively, where P represents the magnetic pole pitch and M represents the phase of the motor.

[0034] Fig. 6 is a schematic drawing of a series arrangement of armature units according to another embodiment of the present invention. Fig. 6 shows a two-phase linear motor, wherein four armature units are arranged in series, of which two each armature units form one phase, and the magnetic pole tooth pitch between two adjacent armature units of the same phase is (K P) {K=0, 1, 2, ...} and the magnetic pole tooth pitch between two adjacent armature units of different phases is (K P+P/M) {(K=0, 1, 2, ...), (M=2, 3, 4, ...)} {K is an optional number not exceeding the maximum number of adjacent armature units to be installed, and M is the phase of the motor} provided that the magnetic pole pitch is P. 6 (a) shows the Phase A - Phase B - Phase A - Phase B arrangement of the armature units. 6 (b) shows the Phase A - Phase A - Phase B - Phase B arrangement of the armature units.

[0035] When multiple armature units are installed to form one phase as shown in Fig. 6, greater thrust can be attained by the linear motor. Although Fig. 6 covers a linear motor wherein four armature units are installed of which two each armature units form one phase, the above explanation applies to an arrangement of multiple armature units in series. The same applies to an arrangement of multiple armature units in parallel and combination of multiple needles into a piece.

[0036] Fig. 7 shows another embodiment of the needle in the present invention. The needle 6 in Fig. 1 is equipped with multiple permanent magnets 7 so that the polarity is alternated between two adjacent magnetic poles. The needle 6 in Fig. 7, however, employs a flat ferromagnetic material instead of the permanent magnets 7, and a raised magnetic pole tooth 13 is provided at a constant interval on both sides of the ferromagnetic material.

[0037] When raised magnetic pole teeth 13 are provided on both sides of the ferromagnetic material, the magnetic resistance between the armature and the magnetic pole surface varies. That is, the magnetic resistance between the raised magnetic pole tooth 13 and the magnetic pole surface of the armature is lower than the magnetic resistance between the flat section 16 of the ferromagnetic material and the magnetic pole surface of the armature. By utilizing the variation of the magnetic resistance, a freely moving needle can be obtained.

[0038] In the above construction, it is possible that the raised magnetic pole teeth 13 are made of ferromagnetic material and the flat sections 16 are made of permanent magnet, forming a combined needle. It is also possible to combine the raised magnetic pole teeth 13 made of ferromagnetic material with the flat sections 16 made of non-magnetic material.

[0039] Fig. 8 shows an example where the flat needle in Fig. 7 is made into a tubular needle. Ferromagnetic materials 36 and non-magnetic materials 37 are combined on a shaft 35. Permanent magnets can also be employed.

[0040] Fig. 9 shows another embodiment of the needle in the present invention. In Fig. 9, the needle 9 is constructed into an endless belt or chain in which the ferromagnetic materials 34 are embedded. Permanent magnet can be employed instead of the ferromagnetic material.

[0041] A method of manufacturing a linear motor according to the present invention is explained hereunder.

[0042] Fig. 10 is an exploded view of the linear motor in Fig. 1. Each of the magnetic poles 1 and 2 and magnetic pole teeth 11a, 12b, 21b, and 22a is manufactured separately, and the magnetic pole 1 and magnetic pole teeth 11a and 12b are put together and the magnetic pole 2 and magnetic pole teeth 12b and 22a are also put together, forming an armature unit. For this, it is possible to press out the magnetic pole and upper and lower magnetic pole teeth for each side in one piece and put the two sides together into a unit. It is also possible to press out all the magnetic poles and upper and lower magnetic pole teeth for two sides in one piece.

[0043] The support mechanism (on the armature side) 14, mounted on the armature unit, supports the needle vertically and horizontally.

[0044] Fig. 11 shows another manufacturing method of a linear motor according to the present invention. With this manufacturing method, a magnetic pole unit 31A comprising an armature core to be wound with a coil 4, magnetic poles on both sides, an upper magnetic pole tooth 11a, and an opposing lower magnetic pole tooth 21b is manufactured in one piece from laminated steel plate.

[0045] The magnetic pole unit 31A installed to an opposite orientation serves as the other magnetic pole unit 31A'. A support structure 32 and a duct 33 are installed between the magnetic pole unit 31A and the other magnetic pole unit 31A'. As a result, the armature is so constructed that the (2n-1)-th unit is the magnetic pole unit 31A corresponding to the first opposing section and the (2n)-th unit is the other magnetic pole unit 31A' corresponding to the second opposing section.

[0046] It is also possible to manufacture the magnetic pole units 31A and 31A' separately in a right-hand half and a left-hand half and put the halves together into a

unit so as to sandwich the coil 4 from both sides.

[0047] Although the preferred embodiment of the present invention has been explained above making reference to a linear motor, the needle and armature unit of the present embodiment are applicable to a vibration type linear actuator in which the needle moves relatively in reciprocation as the DC current is supplied to the coil of the armature unit.

[Effects of the Invention]

[0048] According to the present invention, as explained above, the magnetic path of a magnetic circuit of effective fluxes becomes shorter and accordingly magnetic flux leak can be reduced.

[0049] Besides, as a result that the overall attraction forces between the needle and the armature, acting perpendicularly to the moving direction of the needle, are cancelled each other to zero, the attraction force between the needle and the magnetic pole surface of the armature can be reduced and accordingly a burden on the support mechanisms can be minimized.

[0050] In addition, the armature according to the present invention can be manufactured easily and effectively by manufacturing an armature unit in separate pieces wherein a magnetic pole unit comprising an armature core to be wound with a coil, magnetic poles on both sides, an upper magnetic pole tooth and an opposing lower magnetic pole tooth is manufactured in one piece from laminated steel plate.

Claims

1. A linear motor comprising an armature and a needle with magnetism, the armature being equipped at least with a magnetic pole of a first polarity having a first opposing section and another magnetic pole of a second polarity having a second opposing section, and the needle being placed between the first opposing section and also between the second opposing section.

2. A linear motor comprising an armature and a needle having magnetic poles, wherein the relative position of the needle perpendicular to the moving direction is maintained by an interaction between the armature and the needle.

3. A linear motor according to Claim 1 or Claim 2; wherein, when multiple armature units are installed and the magnetic pole pitch is assumed to be P, the magnetic pole tooth pitch between two adjacent armature units is (K.P+P/M) {(K=0, 1, 2, ...), (M=2, 3, 4, ...)} {K is an optional number not exceeding the maximum number of adjacent armature units to be installed, and M is the phase of the motor}.

4. A linear motor according to any one of Claims 1 to 3; wherein, when multiple armature units are installed, of which two or more armature units form one phase, and the magnetic pole pitch is assumed to be P, the magnetic pole tooth pitch between two adjacent armature units of the same phase is (K.P) {K=0, 1, 2, ...} and the magnetic pole tooth pitch between two adjacent armature units of different phases is (K.P+P/M) {(K=0, 1, 2, ...), (M=2, 3, 4, ...)} {K is an optional number not exceeding the maximum number of adjacent armature units to be installed, and M is the phase of the motor}.

5. A linear motor according to any one of Claims 1 to 4; wherein the magnetic pole tooth pitch of the armature units is either equal to or different from the magnetic pole pitch of the needle.

6. A linear motor according to any one of Claims 1 to 5, wherein there is provided a support mechanism for supporting the needle that moves relatively in the gap of the armature unit.

7. A manufacturing method of a linear motor comprising an armature and a needle having magnetic poles, wherein an armature core to be wound with a coil, magnetic poles on both sides, and a magnetic pole unit integrated from upper magnetic pole teeth and opposed lower magnetic pole teeth are manufactured separately from laminated steel plate to form an armature unit, and an armature equipped with a magnetic pole of the first polarity having the first opposing section and another magnetic pole of the second polarity having the second opposing section is constructed by assembling the separately manufactured armature unit.

FIG. 1

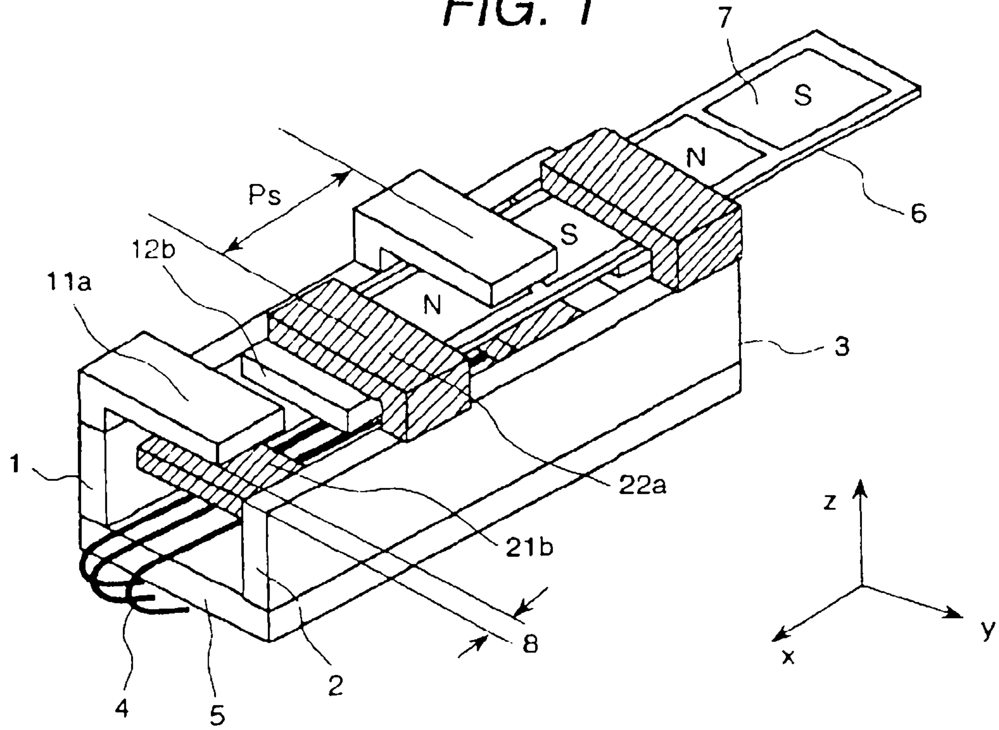

7
S
N
Ps
S
6
12b
11a
N
3
1
22a
21b
z
y
x
8
4
5
2

FIG. 2

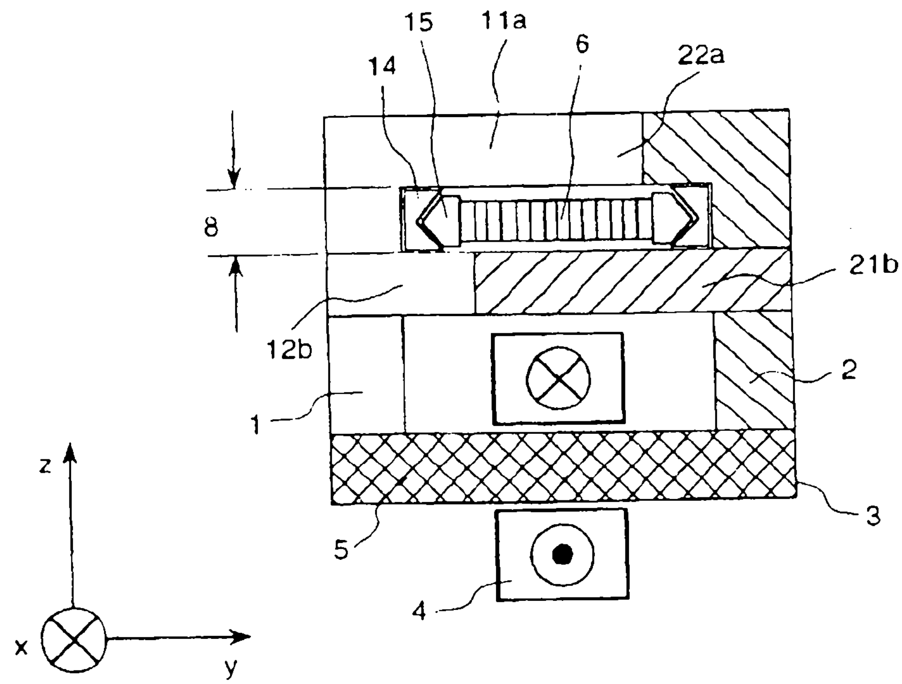

15
11a
6
22a
14
8
21b
12b
2
1
3
5
4
z
x
y

FIG. 3

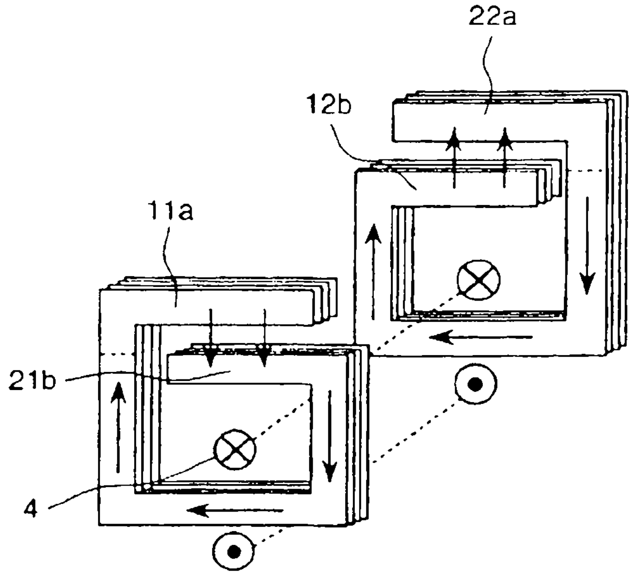


FIG. 4

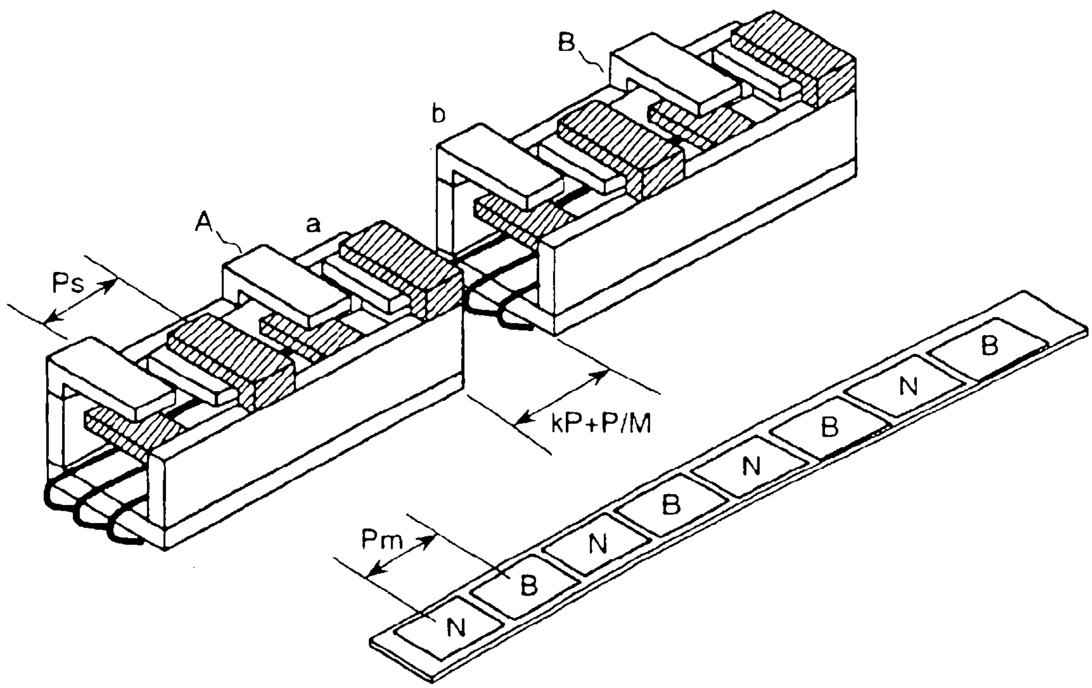


FIG. 5

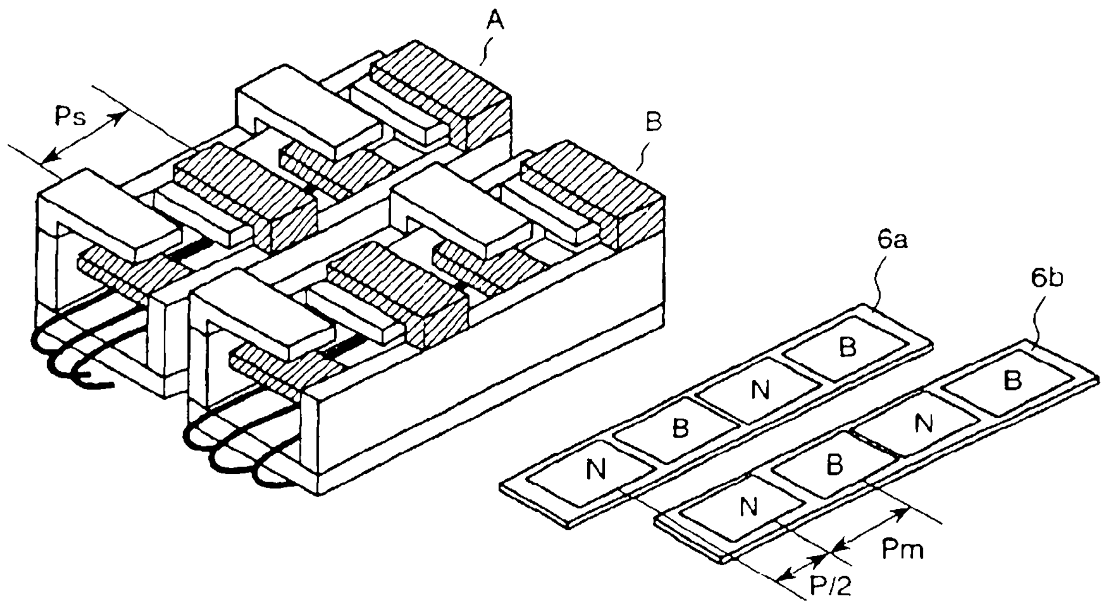
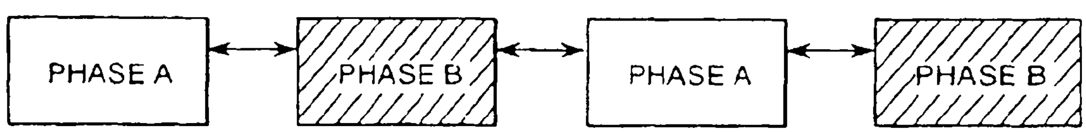
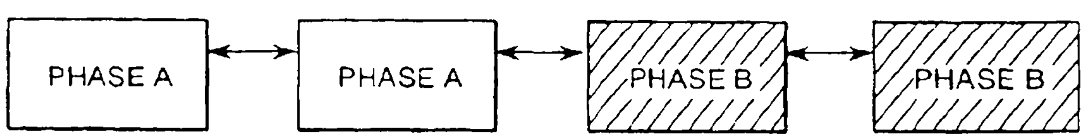


FIG. 6



(A) PHASE A-PHASE B-PHASE A-PHASE B
ARRANGEMENT OF ARMATURE UNIT



(B) PHASE A-PHASE A-PHASE B-PHASE B
ARRANGEMENT OF ARMATURE UNIT

FIG. 9

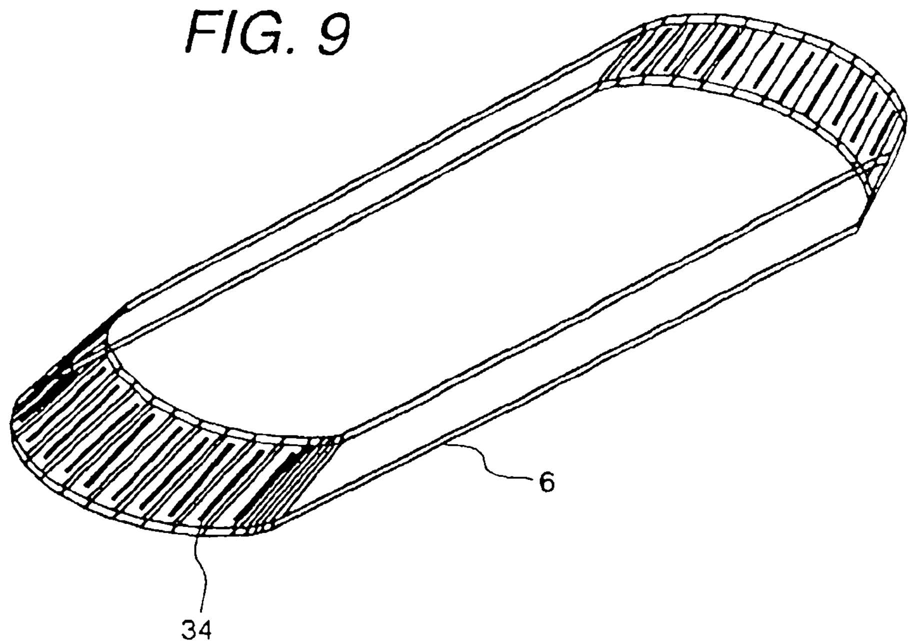


FIG. 10

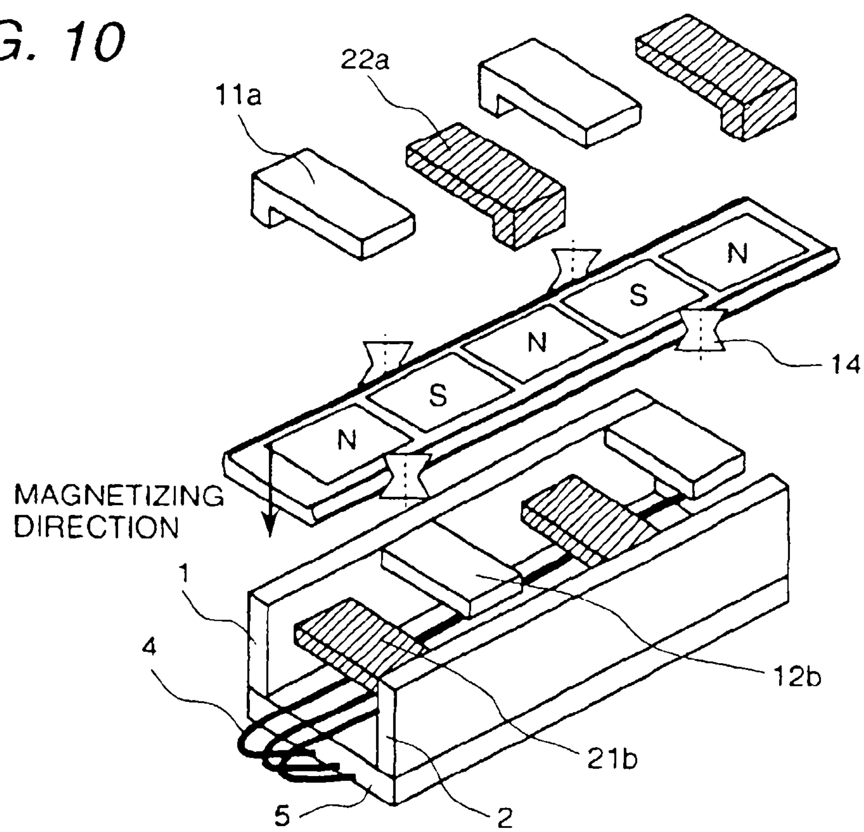


FIG. 7

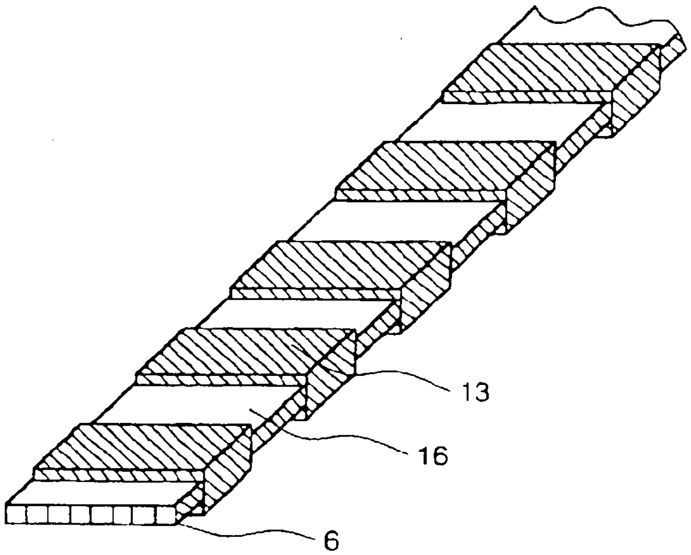


FIG. 8

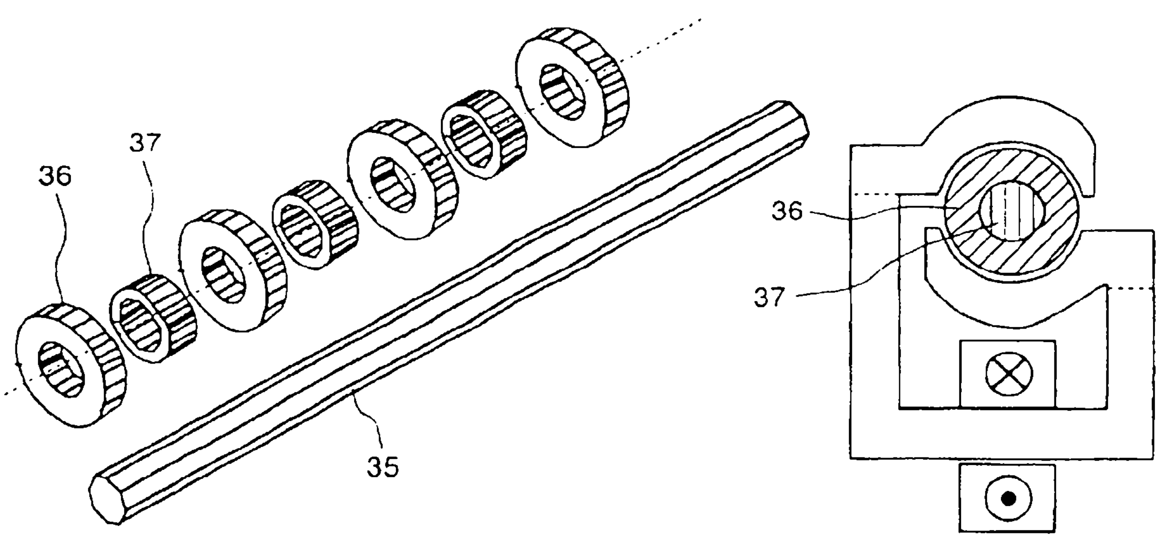


FIG. 11

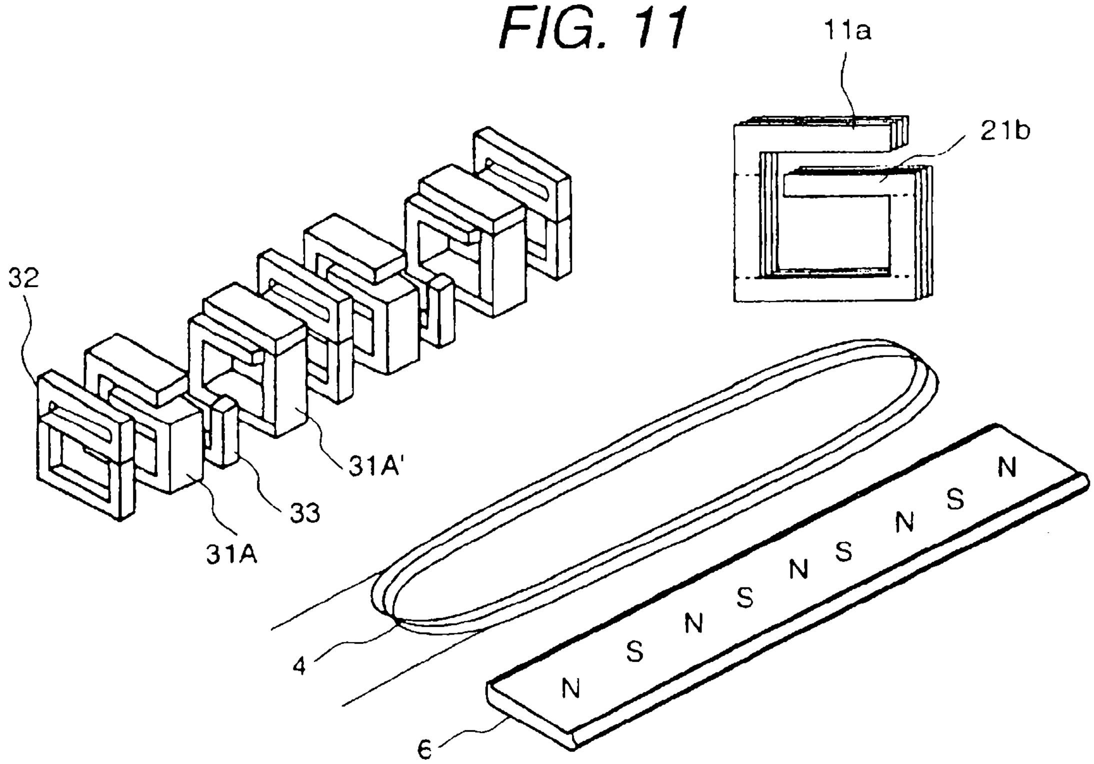
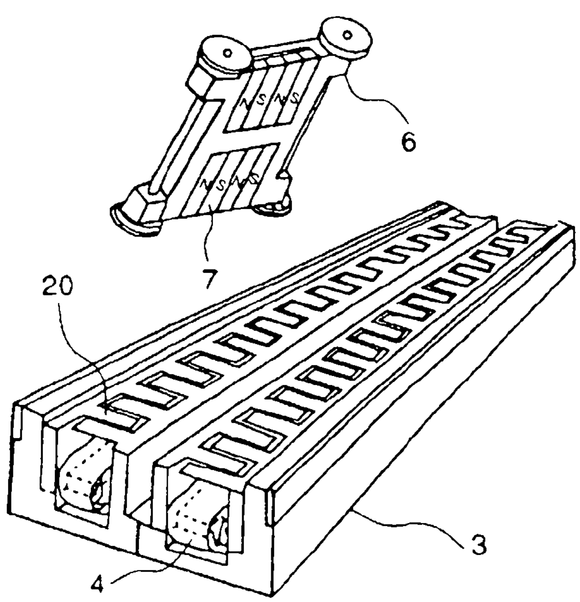


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP00/02808

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^{7} H02K41/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^{7} H02K41/02-41/035

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Toroku Koho 1926-1995 Jitsuyo Shinan Toroku Koho 1996-2000
Kokai Jitsuyo Shinan Koho 1971-1994 Toroku Jitsuyo Shinan Koho 1994-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, 5661350, A (Ecole Nomal Superieure de Cachan), (26.08.97) & WO, 9410742, A1 & JP, 8-502880, A (Ecole Nomal Superieure de Cachan), 26 March, 1996 (26.03.96) & FR, 2697695, A1 & EP, 667991, A1 & EP, 667991, B1 & DE, 69307920, E & ES, 2098797, T3	1-7
A	JP, 63-95849, A (Yasukawa Electric MFG Co., Ltd.) 26 April, 1988 (26.04.88) (Family: none)	1-7
A	JP, 63-107452, A (Omron Tateishi Electronics Co.) 12 May, 1988 (12.05.88) (Family: none)	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 July, 2000 (31.07.00)	08 August, 2000 (08.08.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.